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The titles of the three papers on tonight's program contain the words "Unitary Plan" which may require some explanation for many of you. Immediately following the war in the fall of 1945 both the Military services and the NACA made studies of the wind tunnel equipment required to give a sound basis for the future development of aircraft and missiles. It was realized that progress would soon lead to supersonic aircraft and to the further development of missiles of speeds even greater than that of the V-2.

The early studies were independent and each recommended new research centers with a combined cost of over two billion dollars. Joint discussions led to a coordinated plan which in the form submitted early in 1947 to the Joint Research and Development Board of the Department of Defense reduced the cost estimate to about one billion dollars. The agencies of the Department of Defense in July of 1947 recommended a part of this program estimated to cost 600 million dollars. I do not have time to review all the details. A more complete history is given in the NACA Annual Report for 1953. The first authorization of 146 million dollars for the NACA part, of which 10 million dollars was for wind tunnels at educational institutions, and 100 million for the Air Force part of the plan was made in the Unitary Plan Act of 1949. The sum of 75 million dollars was appropriated for the NACA part in June of 1950. No funds were provided for wind tunnels at educational institutions. The Unitary Plan, as finally implemented, consisted of five wind tunnel installations, of which three were built at existing NACA laboratories and two long with an engine test facility at a new Air Force research center, the Arnold Engineering Development Center at Tullahoma, Tennesee. All of the wind tunnels of the Unitary Plan were built and will be operated primarily to meet the needs of industry and the military for that final large Reynolds number testing of supersonic aircraft and missiles which forms the basis for investing millions of dollars in prototypes and billions in construction. Each of the five installations was designed to meet a specific need, the Langley 4-foot primarily for supersonic missile development, the Ames 8-foot primarily for development of supersonic airplane configurations, the Lewis 10-foot primarily for powered models and propulsion problems, the AEDC tunnels for full-scale engines at transonic and supersonic speeds and for hypersonic missile development.

The three NACA unitary wind tunnels were built at a total cost of 75 million dollars and required 4 to 5 years to build. The papers on our program will describe the three installations which are now going into service.

Advances in aeronautics have been greatly dependent on the use of wind tunnels as tools of research and development. No other field of engineering except perhaps the more modern field of nuclear engineering has found it necessary to place such great reliance on direct experimental measurements in facilities of large size and cost. The interplay of aerodynamic theory and experiment is constantly improving rational design procedures whose accuracy and limits of applicability have been established. However, in spite of years of effort, we do not yet have sufficient knowledge to compute the forces on a body of arbitrary shape in the detail and with the accuracy needed. By the use of models, complex problems of aerodynamics as applied to aeronautics may be investigated in suitable wind tunnels without complete knowledge and understanding of all the details of the actual fluid motion. Investment of large sums of money in prototype aircraft can thus be made with considerable assurance of success.

In advancing the science of aerodynamics much use has been made of small inexpensive wind tunnels especially in exploratory work. Thus supersonic jets a few tenths of an inch in diameter were used by Mach and Salcher in 1889. Supersonic facilities grew to a few inches in size in the 1920's. When, however, technology advanced to the practical design of supersonic missiles and aircraft, larger equipment became a true economy in the over-all development program. By long experience it has been found necessary to have a wind tunnel throat dimension of at least 4 feet and preferably 8 or 16 feet in order that the necessary detail may be reproduced in the model. Moreover to assure reliability of the results the wind tunnel is often operated under pressure to increase the Reynolds number, a quantity which measures the equivalent scale of the model. Before 1930 the growth of wind tunnels as research and development tools involved mainly an increase in Reynolds number, to some extent by increasing air speed but more often by increasing tunnel size or the use of compressed air. The full scale tunnel of 1931 and the variable density tunnel of 1923 were landmarks in this development.

Although the necessity for large supersonic wind tunnels was realized at the close of the war, the performance of special research airplanes equaled wind tunnel performance for a brief period. For the past six years the maximum speed of available large supersonic wind tunnels has been about twice the speed of sound (Mach number 1.9 to 2.2). The history over the recent period is shown in Fig. 2. A lead of about 3 or 4 years has been maintained since 1948 but this has now been lost. On October 14, 1947 Captain Charles E. Yeager, USAF, attained supersonic speed in the Bell X-1 research airplane and soon thereafter reached a speed of 936 mph (Mach number 1.4). William Bridgeman in the Douglas Skyrocket reached 1238 mph (Mach number 1.86) in August 1951 and NACA Research Pilot Scott Crossfield reached 1327 mph (twice the speed of sound) on November 20, 1953. On December 12, 1953 Yeager flew at a speed nearly $2\frac{1}{2}$ times the speed of sound in the Bell X-1A. When in 1944 the planning began which finally resulted in the Unitary Wind Tunnels now nearly completion, the maximum speed of airplanes was slightly over 500 miles per hour. Speeds of 1300 or 1600 miles per hour seemed but wishful thinking. Yet a piloted airplane has now actually flown faster than the speed available in any wind tunnel suitable for development tests.